NAVAL HEALTH RESEARCH CENTER

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Summary

Explosive Ordnance Disposal (EOD) work involves the handling and movement of heavy ordnance both in the water and on land, tasks that are physically demanding. A review of the literature suggested that there are questions concerning the physical abilities required for EOD work, and the ability of the current Navy Physical Readiness Test (PRT) to reflect those abilities.

The purpose of this study was to explore relationships between performance of simulated EOD job tasks and measures of physical fitness and to determine minimum physical fitness scores that might serve as standards for EOD personnel.

Methods

Subjects were 47 active-duty U.S. Navy EOD personnel. Forty-five were male, two were female. Twenty-eight were drawn from units stationed on the East Coast, 19 from units on the West Coast. Participants' mean age was 31.8 ±5.8 years; stature, 177.4 ±5.8 cm; body mass, 81.1 ±10.9 kg; and body fat content, 17.1 ±5.3%.

The following physical fitness attributes were measured: Sit-reach distance (AAHPHERD, 1984), maximum number of push-ups in 2 min, maximum number of curl-ups in 2 min, maximum number of pull-ups, standing long jump distance, time to run 1.5-mile (2.41 km) and 3.0 mile (4.83 km), time to swim 500 yards (457.2 m) in a pool, and time to swim 1,000 yards (914.4 m) in the open ocean.

Performance on a set of four job task simulations was measured. The simulations were developed from a previous job task analysis and consisted of (1) carrying diving equipment, totalling 360 pounds, out and back on a 25-yard course; (2) lifting 5 sets of twin-80 SCUBA tanks from the ground to the deck of a trailered Boston Whaler; (3) swimming a distance of 500 yards on a bay surface using snorkel and wearing full wet suit, twin 80s, and a partially inflated life vest and fins; and (4) swimming 100 yards on the bay surface with a disabled partner who is wearing an inflated life vest. For each simulation, performance was measured as time to complete the task.

Results and Discussion

This sample of EOD personnel was found to be very fit by Navy standards. Thirty-nine of 47 individuals scored "outstanding" based on their PRT item performances. The remaining eight scored "excellent."

Mean performances (±SD) on the job task simulations were 2.45 (±0.43) min for the equipment carry, 0.40 (±0.16) min for the SCUBA tank lift, 13.75 (±1.77) min for the surface swim,

and 3.09 (±0.58) for the rescue swim.

Fat-free mass was a significant predictor ($p < 0.05$) of performance on all of the job task simulations. Body mass was a significant predictor of performance on the SCUBA tank lift, bay swim time, and rescue swim time. Stature was significantly related to equipment carry time and bay swim time. The PRT items were, in general, poor predictors of performance on the job task simulations, with the only significant prediction being push-ups of performance on the bay swim and rescue swim.

Conclusions

From the findings of this study we conclude: (1) PRT items are not good indicators of physical readiness for EOD job tasks; (2) readiness for EOD work can best be assessed by administration of the job tasks developed for this study; (3) maintenance of a score of "excellent" or better on the PRT is a rough indicator of suitability for EOD work; (4) a strength or power test may have utility in predicting readiness for EOD work, borne out by the finding that fat-free mass had the greatest correlations among the predictors with job task performance and, that the job tasks are of such short duration that aerobic processes are not key to performance; and (5) no suitable basis exists for adding measures such as pull-ups, long-jump and 3-mile run to the PRT for EOD personnel.

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Introduction

The purpose of this study was to explore relationships between performance of simulated Explosive Ordnance Disposal (EOD) job tasks and measures of physical fitness, and to determine minimum physical fitness scores that might serve as standards for EOD personnel.

The Navy's physical readiness instruction, OPNAVINST 6110.1D, requires a minimum level of physical fitness for all sailors. However, the instruction does allow "certain specialized warfare occupations and training/accession programs" to "require more stringent standards than those outlined in [the] instruction." EOD appears to be an occupation that requires more stringent physical standards.

In accordance with OPNAVINST 6110.1D, the Navy administers its Physical Readiness Test (PRT) twice each year. This test consists of: (1) a demonstration of the ability to touch one's toes while seated with the legs extended, (2) measurement of the number of curl-ups that can be completed in 2 min, (3) measurement of the number of push-ups that can be completed in 2 min, and (4) time for either a 1.5-mile run or a 500-yard swim using any stroke. This test provides measures of muscle endurance and cardiovascular-respiratory endurance, but not muscle strength.

EOD work involves the handling and movement of heavy ordnance, both in the water and on land. These tasks are physically demanding and it is unclear whether the greatest physical demands will be associated with work in the water or on land. Water is about 60 times as viscous, 800 times as dense, and has nearly 25 times the thermal conductivity of air at the Earth's surface. These properties and the resultant buoyant effects on objects and on individuals working in this environment can alter the effort required to perform physical work (Egstrom and Weltman, 1974). In situations where the diver can support himself against the sea bottom or other objects, the work required to move objects can actually be less than that required to move the same objects on the surface. This is a result of the buoyant effects of the water on the object being moved. When the diver cannot support himself, the cost of such work is higher than on land. Dwyer's studies (1975) suggest that as depth increases, the oxygen consumption required to perform work increases. However, the magnitude of this increase is small. The oxygen consumption rate required to swim with a given resistive load is approximately 6% greater at 99-feet sea water than at 33-feet sea water.

The EOD community has proposed, and in some cases implemented, physical fitness standards that exceeded those contained in OPNAVINST 6110.1D. As an example, EOD Mobile Unit Three has promulgated an instruction (EODMUTHREEINST 6110.1A) that calls for the inclusion of a 1,000-yard ocean swim and substitution of a 3-mile run (for the 1.5-mile run) in their PRT. However, these standards were not developed from documented job task requirements. In order to avoid challenge to standards that differ from the Navy's general requirements, it is mandatory that a relationship between these more stringent standards and the physical requirements of EOD work be documented.

Physical conditioning programs also have been proposed for the diving community (Doubt and Mecocci, 1985). These programs are not based on an analysis of the physical requirements of the job. In the case of the cited work, the program was developed to prepare divers for research studies.

There is some question about the physical abilities that are needed in EOD work. In a study of 46 EOD trainees, Hogan (1985) found that cardiovascular endurance, muscle endurance, flexibility, and neuromuscular coordination, but not muscle strength, are related to success in dive school for Navy EOD trainees. However, in a larger sample (97), Hogan and Hogan (1985) later found strength and power tests have the highest correlations with EOD training course success. Hodgdon (1992, unpublished data) found for Special Warfare trainees at Basic Underwater Demolition and SEAL training that endurance performance (time to swim 300 yards and time to run 1 mile), but not strength performance, predicts success in the course. The value of these findings for active-duty forces depends upon the extent to which these diver-training programs actually relate to on-the-job requirements, a relationship that is not clear.

Beckett and Hodgdon (1987) have explored use of PRT test items to predict lifting and carrying capacities in a sample of 102 (68 male, 34 female) active-duty Navy personnel. Lifting capacity was determined using two lifts: maximal box load that could be lifted to knuckle height, and maximal box load that could be lifted to elbow height. Carrying capacity was determined as the maximum distance covered during each of two 5-min periods (separated by 1-min rest) carrying a 34.02 kg box on alternate trips along a closed loop, 51.8 m in length. Table 1 contains the correlations between PRT items and lifting and carrying capacities. While each of the PRT items has a significant association with at least one of the capacities, the correlations generally are not sufficiently strong to provide a practical basis for assessment of lifting and carrying abilities. In fact, no multiple regression to predict lifting and carry-

Table 1. Correlations* Between PRT Items and Lifting and Carrying Capacities

	Elbow-ht Lift (N = 98)	Knuckle-ht Lift (N = 99)	Carry Distance (N = 100)
Curl-ups	-0.01	0.06	**<u>0.30</u>**
Push-ups	**<u>0.63</u>**	**<u>0.58</u>**	**<u>0.57</u>**
1.5-mile run time	**<u>-0.34</u>**	**<u>-0.36</u>**	**<u>-0.67</u>**
Sit-reach distance	**<u>-0.21</u>**	-0.18	0.02

*Significant correlations ($p < 0.05$) are indicated in bold and underlined.

ing task performance from PRT test item performance produced a multiple correlation higher than 0.71 (prediction of box carry distance from 1.5-mile run time and number of push-ups in 2 min; standard error of estimate 111.9 m).

These past findings suggest that questions concerning the physical abilities required for EOD work, as well as the ability of the PRT items to reflect those abilities, are open to question. Therefore, a study was conducted to define a set of job task simulations that reflect EOD work and to determine associations between performance on those tasks and PRT item performance.

Methods

Subjects

Subjects were 47 active-duty U.S. Navy EOD personnel. Forty-five were male, two were female. Twenty-eight were drawn from units stationed on the East Coast, 19 from units on the West Coast. Physical characteristics of the subjects are provided in Table 2.

Table 2. Participant Physical Characteristics

Variable	*Mean (± std. dev)*	*Range*
Age (years):	31.8 ± 5.8	22 - 45
Stature (cm):	177.4 ± 5.8	165.1 - 189.2
Body Mass (kg):	81.1 ± 10.9	54.9 - 102.5
Body Fat Content (% of mass):	17.1 ± 5.3	5.5 - 29.2

Physical Measurements

Physical measurements of the subjects were as follows: stature and mass were determined wearing running shorts. Body girths were measured at the neck and level of the umbilicus for men, and at the neck, natural waist, and hips for women, using the techniques described in Beckett & Hodgdon (1984). Circumference values were used with stature to estimate body fat content (Hodgdon & Beckett, 1984a, 1984b). This method is used by the Navy to assess compliance with Navy body fat standards (U.S. Department of the Navy, 1990).

Physical Fitness Battery

The following physical fitness attributes were measured: Sit-reach distance (AAHPHERD, 1984), maximum number of push-ups in 2 min, maximum number of curl-ups in 2 min, maximum number of pull-ups, standing long jump distance, time to run 1.5-mile (2.41 km) and 3.0

mile (4.83 km), time to swim 500 yards (457.2 m) in a pool, and time to swim 1,000 yards (914.4 m) in the open ocean.

The body composition assessment, sit-reach distance measurement, sit-up and push-up performance, time for the 1.5-mile run, and time for the 500-yard swim are items in the Navy PRT (although usually only the run or the swim is performed as an aerobic test). The pull-ups, 3-mile run time, and the 1,000-yard bay swim are additional items used for physical fitness assessment by the EOD community.

<u>Model Job Tasks</u>

Task Analysis.

A task analysis to determine the most physically demanding tasks performed by EOD personnel was carried out in collaboration with an outside contractor. The results are reported elsewhere (Prusaczyk et al., 1998). A list of physically demanding tasks was identified through interviews with subject matter experts (senior EOD personnel). A separate sample of EOD personnel then rated the tasks on the list for difficulty, importance, and frequency. In addition, the members of the rating sample were asked to indicate which of the tasks that he/she had performed (1) regularly required the most muscle strength, (2) required the most muscle strength, (3) regularly required the most stamina, (4) required the most stamina, (5) want everyone in the team to be able to perform, (6) regularly was the most physically demanding, and (7) was the most physically demanding. Responses to these questions were used in selecting the final tasks.

Job Task Selection.

Job tasks for modeling were selected among those tasks that were most frequently rated as being in the top of one of the categories (i.e., difficulty, importance, or requiring the most strength or endurance on a regular or one-time basis). Selection was constrained in that the job task had to be performed individually to allow assessment of the individual's suitability. In addition, the task simulation had to be practical to model. It couldn't demand an inordinate amount of equipment or environmental conditions that could not easily be replicated. Each of these constraints led to the elimination of tasks that may have been more demanding than those selected. For example, the task "Carry a 100-kilogram bomb 100 feet using a 'hernia bar' with a partner" was most frequently selected as the task requiring the most muscle strength. It was ruled out for modeling because it required two individuals to accomplish. The task most frequently picked as the physically demanding activity that the respondent would want everyone on the team to be able to perform was "Rescue a disabled dive partner weighing 185 pounds from a depth of 60 feet (both you and partner wearing twin 80s)." This task was ruled out for modeling because it required that a volume of water 60 feet in depth be found to run the simulation.

Selected Job Tasks.

Four tasks were selected:

1. *Dive equipment carry.* EOD task from the analysis: Carry diving equipment from truck or dive locker to a small boat (6 trips at 60 pounds each). Simulation: Carry diving equipment on an out-and-back course, 25 yards in length. The diving equipment was picked up and returned at the same spot. Trips carrying equipment were alternated with trips carrying nothing. The equipment to be moved consisted of 2 dive bags (60 pounds each), 2 weighted boxes (60 pounds each), 1 pair of gas cans (40 pounds total), and 1 set of SCUBA tanks (80 pounds) weighing a total of 360 pounds. Test participants were allowed to choose the order in which they carried the equipment. The number of trips required moving the equipment was not fixed. Performance was measured as the time to complete movement of all the equipment. Figure 1 depicts a subject performing the dive equipment carry simulation.

Figure 1. Dive equipment carry.

2. *SCUBA tank lift.* EOD task from the analysis: Lift SCUBA tanks (twin-80s weight in 80 pounds) to eye level to pass to personnel aboard support craft. Simulation: Lift 5 sets of twin-80 SCUBA tanks (80.5 pounds each) from the ground to a buddy standing on the deck of a trailered Boston whaler (68 inches). Performance was scored as time to complete lifting all 5

Figure 2. SCUBA tank lift

sets of tanks. Figure 2 depicts a study participant performing the SCUBA tank lift.

3. *Surface swim.* EOD task from the analysis: Swim on surface a distance of 500 yards, wearing a full wet suit, twin 80s, a partially inflated life vest, and fins in 4-foot swells against a 1-knot current. Simulation: Swim bay surface, using a snorkel, a distance of 500 yards, wearing full wet suit, twin 80s, and a partially inflated life vest and fins. Participants were allowed to swim on their backs (turtle) or stomachs, as they chose, along a 250-yard out-and-back course in a calm bay. Performance was scored as time to complete the course. Figure 3 shows a study participant dressed out for the swim, entering the water, and performing the swim.

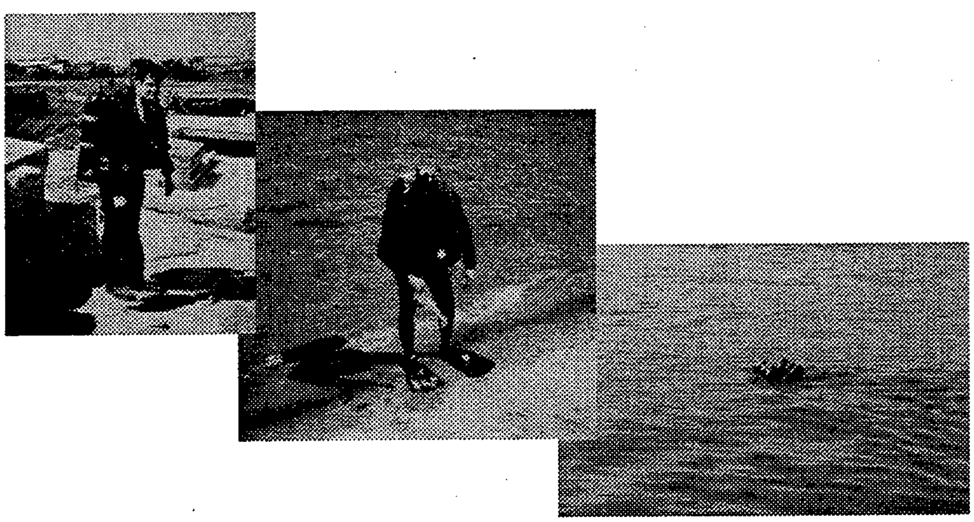

Figure 3. Surface swim

4. *Rescue swim.* EOD task from the analysis: Swim on calm sea surface a distance of 100 yards with a disabled dive partner who weighs 185 pounds and is wearing an inflated life preserver. Simulation: Swim 100 yards on bay surface with a disabled dive partner who is wearing an inflated life vest. Again, performance was measured as the time to complete the task. Figure 4 shows a study participant and "victim" performing the rescue swim.

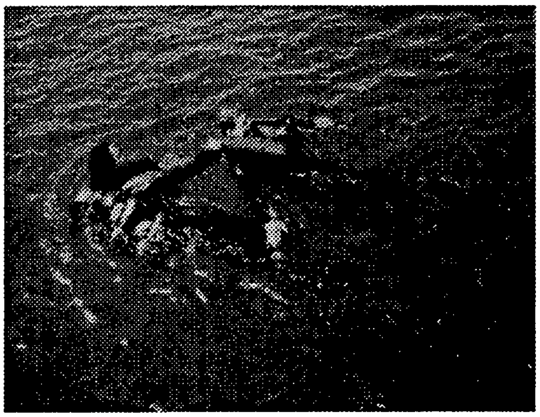

Figure 4. Rescue swim

The job task simulations were administered serially to all participants in a fixed order: the carry task, followed by the lifting task, followed by the swim task, and lastly, the rescue task. In addition, a fixed time was provided between events: 5 min between the carrying and lifting tasks, 15 min between the lifting and swimming tasks, including time to don the wet suit and gear, and 15 min between the swim task and rescue tasks.

Procedures.

Briefings on the nature of the study, the use of the information to be collected, and the risks attendant with participation were provided to potential study participants. Those who chose to participate gave their informed consent in accordance with Naval Medical Research and Development Command Instruction 3900.2. Data for this study were collected over the course of 5 sessions, each separated by at least one full day, and conducted within a 2-week period.

During the first session, physical measurements were obtained, and sit-reach distance, maximum number of curl-ups in 2 min, maximum number of push-ups in 2 min, maximum number of pull-ups, and time for the 3-mile run/walk were measured. In the second session, time for the 1,000-yard bay swim in life vest and fins was measured. The third session consisted of measurement of long jump distance and time for the 1.5-mile run/walk. Time for the 500-yard pool swim was measured during the fourth session. During the last session, performance on the job task simulations was measured.

Results

Physical Fitness Battery.

Table 3 provides a summary of performance on the physical fitness tests. The 1,000-yard bay swim was recorded under different conditions during West and East Coast administrations. For this reason, separate performance values are given in Table 3. On the West Coast, bay

Table 3. Physical Fitness Values
(N = 47)

Measure	Mean (± std. dev.)	Range
# Pull-ups	11.6 ± 4.7	2 - 22
# Push-ups in 2 min	70.9 ±18.6	36 - 125
# Curl-ups in 2 min	86.7 ±16.6	52 - 123
Long jump distance (in)	88.6 ±9.4	70 - 117
1.5-mile run time (min)	10.3 ±1.2	8.5 - 13.2
3.0-mile run time (min)	22.1 ±2.5	17.8 - 28.7
500-yd pool swim time (min)	10.4 ±1.5	7.6 - 13.1
1,000-yd bay swim time (min)	19.9 ±2.1[1]	16.8 - 23.4[1]
	31.5 ±7.1[2]	20.5 - 50.9[2]
Sit-reach distance (cm)	10.7 ±7.1	-4.0 - 22.0

[1]West Coast sample (N = 19); [2]East Coast sample (N = 28)

swim performance was recorded in a calm bay with virtually no current or swells. During the East Coast administration, a storm blew in and performance was measured during approximately 1-knot currents down leg and 4-foot swells. Weather and constraints on administration time did not allow for readmission of the bay swim.

Table 4 contains the intercorrelation matrix for the physical measurements and the physical fitness tests. Significant correlations are underlined and indicated by bold print. Stature is found to be most strongly associated with fat-free mass. It is also significantly ($p < 0.05$) associated with body mass and long jump distance. The body masses are all significantly interrelat-

Table 4. Correlations among Physical Measurements and Physical Fitness Tests

Measurement:	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Stature	**.50**	**.69**	.02	-.20	-.23	-.05	.05	.23	-.01	-.02	**.42**	.09	.07
2. Body mass	-	**.88**	**.75**	**.50**	-.23	.05	**.32**	.14	-.01	-.22	.03	**.41**	-.01
3. Fat-free mass[1]		-	**.36**	.04	-.17	.15	.04	.14	.05	.06	**.34**	.12	-.05
4. Fat mass[1]			-	**.94**	-.23	-.09	**.59**	.08	-.08	**-.53**	**-.41**	**.64**	.05
5. Percent fat[1]				-	-.12	-.15	**.58**	-.02	-.07	**-.57**	**-.53**	**.61**	.01
6. Curl-ups					-	**.36**	**-.45**	**-.49**	.15	**.41**	.20	**-.42**	**-.64**
7. Push-ups						-	**-.45**	-.23	.22	**.37**	.21	-.28	**-.36**
8. 1.5-mile run							-	**.36**	-.20	**-.55**	**-.37**	**.91**	**.34**
9. 500-yd swim								-	-.26	-.23	.02	.28	**.62**
10. Sit-reach									-	.13	-.03	-.13	-.13
11. Pull-ups										-	**.52**	**-.46**	-.28
12. Long jump											-	-.28	-.04
13. 3-mile run												-	.25
14. 1,000-yd swim[2]													-

ed. Body mass, itself, is significantly and positively associated with the run times as is fat mass. The fat-free mass is not significantly associated with the runs. The pattern suggests that, in this sample, larger individuals tend to be fatter.

Job Task Performance.

Results of the job task simulation are provided in Table 5. The sample size differed among task simulations. The sample size for each task performance is provided in superscript by the task description.

Table 5. Job Task Performance

Job Task	Mean (±Std. Dev.)	Range
Dive equipment carry $^{(N = 44)}$	2.35 ± 0.43	1.65 – 3.63
SCUBA tank lift $^{(N = 44)}$	0.40 ± 0.16	0.23 – 1.07
Surface swim $^{(N = 42)}$	13.75 ± 1.77	10.97 – 18.80
Rescue swim $^{(N = 40)}$	3.09 ± 0.58	2.27 – 5.12

Performances on the job task simulations were not normally distributed. Figures 5 through 8 show the distribution of times to complete each of the job task simulations. In these figures, it can be seen that for each task, the distributions of times for task performance do not appear to be normally distributed. Rather, they are negatively skewed, significantly so for all except the swimming task (t_{42} = 2.61 for the carry task; t_{42} = 6.32 for the lifting task; t_{40} = 1.94 for the swim task; and t_{38} = 3.37 for the rescue task: $p < 0.05$ for all but the swim task).

In order that these "extreme values" not inflate the correlations between the performance measures and the fitness measures, the individual regression equations predicting task performance from each of the physical characteristics and fitness measures were computed and the residuals inspected. If the standardized residual for a case in the regression exceeded a value of 3.0, the value was considered an outlier and the case dropped from the analysis sample. This analysis led to the dropping of one case from analyses involving the carry task, one case involving the lift task, and one from the rescue task. Each of the outliers represented the maximal time for the task performance. Within the regressions involving a particular task performance, the same case appeared as an outlier in each regression involving that task performance.

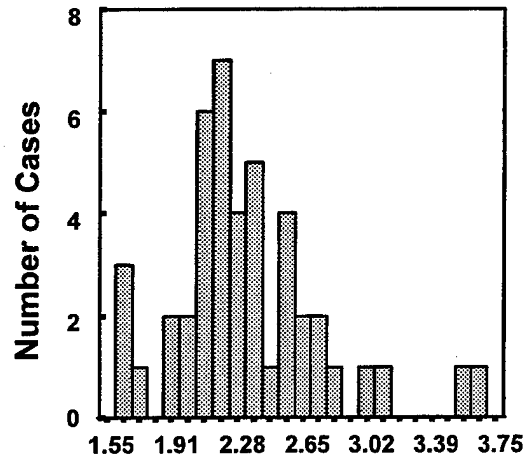

Figure 5. Distribution of equipment carry times.

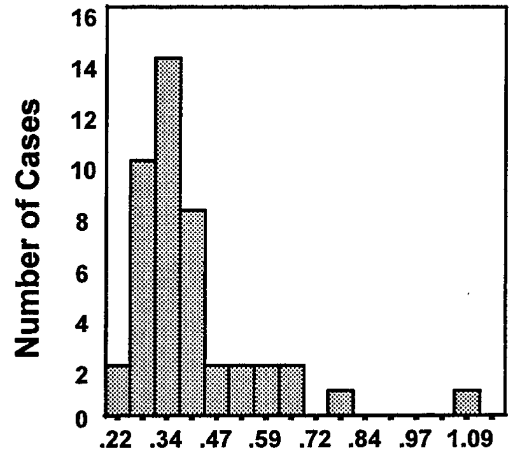

Figure 6. Distribution of SCUBA tank lift times.

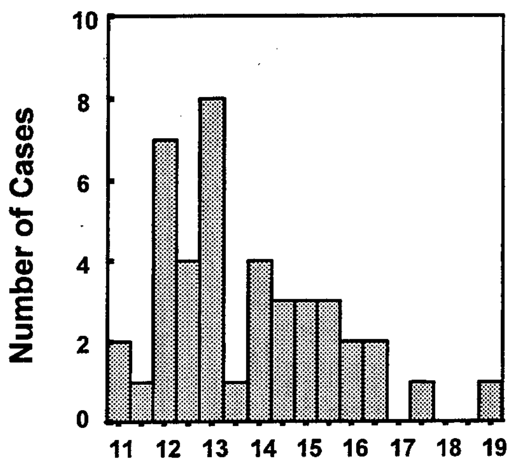

Figure 7. Distribution of 500-yard fin swim times.

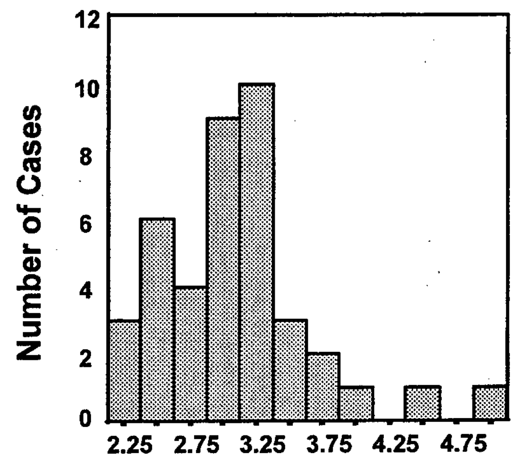

Figure 8. Distribution of 100-yard rescue swim

Physical Fitness and Characteristics and Job Task Performance.

Table 6 shows the Pearson product moment correlations between the physical characteristics and physical fitness test performances, and the job task performance times. Significant correlations are underlined and indicated in bold print. The correlation between the bay swim time and times on the job tasks was calculated using standardized values of the individual bay swim times. This was done because the mean times differed greatly between East and West Coast groups.

Fat-free mass was found to be significantly correlated ($p < 0.05$) with performance on each of the four job task simulations. Body weight correlated significantly with the lifting and

Table 6. Correlations* Between Fitness Measures and Task Performances

	Carry Time	*Lift Time*	*Swim Time*	*Rescue Time*
Stature	**-0.36**	-0.30	**-0.34**	-0.17
Body mass	-0.24	**-0.46**	**-0.47**	**-0.36**
Fat-free mass[1]	**-0.43**	**-0.55**	**-0.55**	**-0.42**
Fat mass[1]	0.13	-0.18	-0.16	-0.11
% fat[1]	0.26	0.08	-0.02	0.06
Curl-ups	0.09	-0.10	-0.10	0.02
Push-ups	-0.05	0.09	**-0.33**	**-0.34**
1.5-mile run time	0.27	0.19	0.13	0.13
500-yd swim time	-0.08	0.13	**0.33**	0.05
Sit-reach distance	0.05	-0.10	-0.20	0.02
# pull-ups	-0.29	0.03	-0.25	-0.18
Long jump	**-0.39**	-0.16	-0.16	-0.08
3-mile run time	0.26	0.12	0.00	-0.07
1000-yd bay swim[2]	0.01	-0.01	**0.40**	0.20

* Significant correlations ($p < 0.05$) are indicated in bold and underlined.

[1] Percent fat was estimated from ci rcumferences and height (see text).

[2] Scores for each group (East Coast/West Coast) were standardized and then combined for this analysis.

swimming tasks. Push-ups were found to correlate significantly with the swimming tasks, and the 500-yard pool swim and 1,000-yard bay swim were significantly correlated with the swim task performance, but not performance on the rescue swim task. Other significant correlations included long jump distance with time on the carry task, and stature with time on the carry and swim tasks.

Discussion

Physical Fitness

By Navy standards (OPNAVINST 6110.1D, 1990), this sample of EOD personnel is very fit. Of the 47 individuals tested, 39 (83%) scored "outstanding" (the highest category) overall on the PRT. The remaining 8 (17%) scored "excellent," the second highest category. Performance on the individual PRT items was more varied. Thirty (63.8%) of the participants scored "outstanding" on the curl-ups, with the remaining 17 (36.2%) scoring "excellent." Virtually all (45 of 47) of the participants scored "outstanding" on the push-ups. The remaining two scored "good," the third highest category. On the 1.5-mile run/walk, the majority of the participants scored "excellent" (26 of 47, 55.3%), with 15 (31.9%) scoring "outstanding," and the remaining 6 participants scoring "good." Performance on the 500-yard pool swim was, for the most part, equally distributed among the top three classifications with 15 (31.9%) scoring "outstanding," 14 (29.8%) scoring "excellent," and another 15 scoring "good." The 3 remaining participants scored "satisfactory." The distribution of these swim scores is not necessarily indicative of PRT performance by the EOD community. It appears from conversations with participants after the pool test, that not all of them understood that they could use any stroke they wished for the pool swim. Some participants assumed they could only use the breaststroke (as is required for some EOD tests). This resulted in a bimodal distribution of PRT swim times (see Figure 5). Since free-style is faster than breaststroke for most individuals, the number of swim performances in the lower categories of "good" and "satisfactory" may be higher than if all participants had chosen the swim stroke that would yield their best time.

A comparison of performance on the physical fitness tests between East and West Coast groups did not reveal significant differences except in push-up performance. On average, East Coast team members performed 79.6 ±16.8 push-ups in 2 min, while their West Coast counterparts performed 58.1 ±13.1 push-ups ($t_{44} = 4.91$; $p < 0.05$). Review of training records for the groups indicated the East Coast group had a much greater volume of push-up training than did the West Coast group. This probably accounts for the performance difference.

Job Task Performance.

Comparison of performances on the job task simulations between East and West Coast groups revealed significant differences between the groups on performance of the carry task (East Coast group mean = 2.5 min, West Coast group mean = 2.2 min; $t_{42} = 2.48$, $p < 0.05$), and the rescue swim task (East Coast group mean = 2.9 min, West Coast group mean = 3.3 min; $t_{38} = 2.60$, $p < 0.05$). In each case, the means differ by about 15%. The basis and importance of these differences is unclear.

Physical Fitness and Characteristics and Job Task Performance.

From Table 4, it appears that the PRT measures (curl-ups, push-ups, 1.5-mile run time, and 500-yard swim time) are not good predictors of job performance, at least as it is indicated by these task simulations. These findings are in keeping with those of Marcinik et al. (1995), who measured performance on the PRT items, the maximum number of pull-ups, and performance on a number of simulated job tasks for fleet divers. Their task simulations consisted of a 60 m swim in SCUBA gear while carrying a tool bag, treading water using fins, descending and ascending a ladder climb, and lifting and carrying SCUBA tanks. They found virtually no association between their physical fitness measures and performance on their simulated job tasks.

There are a variety of reasons why the PRT items may have failed to predict job tasks. As noted above, the participants in this study were all very fit, at least by Navy standards. The modest correlations seen between fitness measures and job task performances may well reflect a restriction of range in one or both sets of measures. In general, the standard deviations and ranges for the fitness measures are smaller than those for comparable measures in the population sample studied by Beckett and Hodgdon (1987).

Additionally, with the exception of the 500-yard fin swim, the tasks in this study were of short duration: about 3 min or less. In work bouts of such short duration, the body has only just mobilized aerobic metabolic processes (McArdle et al., 1991). It is unlikely, then, that measures of aerobic capacity, such as the 1.5-mile run, would be good predictors of job task performance. In the study by Marcinik et al. (1995), the same situation exists. The longest task takes 4.7 min on average.

The 500-yard surface swim required 13.75 min on average to complete. However, since fin swimming is not an activity that requires over 50% of the muscle mass, it too, would not be limited by aerobic capacity. Limitations to performance are more likely related to the ability of the muscles to take up and utilize the oxygen provided rather than the ability of the cardiovascular and respiratory systems to deliver oxygen and other substrates. This conjecture is supported by the finding of a significant correlation between performance on the fin swim and the number of push-ups that can be performed in 2 min This push-up measure is taken to be an indicator of muscle endurance.

Additionally, calisthenic tests such as push-ups, curl-ups, and pull-ups might not be expected to be good predictors of job task performance. Since individuals can differ from one another with respect to stature and mass, these tests represent different amounts of work for different individuals. For example, with the push-up, the mass to be supported with the arms (approximately 43% of body mass) differs among individuals. The force required to move the body mass depends on the length of the lever arm against which the force is applied. This length is determined by body stature. Similar points can be raised in the description of pull-ups and curl-ups. Such tests do not provide the same workload for all individuals, either relative to body mass or absolute, and therefore, are difficult to interpret.

The significant correlation between weight and performance on the lifting and swimming tasks, suggests that increased size is an advantage in performance of these tasks. The significant correlation between fat-free mass and performance on the same tasks suggests a need for strength. The partial correlations between fat-free mass and lifting and swimming task performance when controlling for body weight are significant (r_p = -0.55, $p < 0.001$ between fat-free mass and lift task time; $r_p = 0.32, p < 0.05$ between fat-free mass and swim task time). The partial correlation between rescue swim time and fat-free mass controlling for weight was not significant ($r_p = -0.18, p > 0.05$). None of the partial correlations between weight and task performance was significant when fat-free mass was controlled. One interpretation of these results is that strength is important, in addition to or as an adjunct to size in the accomplishment of the lifting and swimming tasks, but that size, alone, was important in the accomplishment of the rescue task.

Fitness Standards for EOD.

This study does not provide a satisfactory basis for setting PRT standards for EOD personnel. The performance metric for each of the job tasks was time to complete the task. Even after consultation with EOD subject matter experts, we were unable to determine times that represented satisfactory performance on each of these tasks. EOD work is not usually time critical. It is more important that tasks are accomplished properly, than accomplished quickly. It follows then, that it is completion of the job task simulations that represents satisfactory performance. This task battery was developed with the EOD community to be content valid. Therefore, if there is a question of an individual's ability to meet the physical demands of EOD work, he/she should be administered this job task battery.

All the participants in this study could complete the tasks, and thus the lowest performance on the PRT among the participants offers the best definition of minimal PRT standards for EOD work. While there was some variation in the performance levels achieved on the individual PRT items, a consistent finding was that all EOD personnel in this sample achieved a rating of "excellent" or better on the PRT, as a whole. This probably represents the most reasonable "goal" that could be set for EOD PRT performance. However, this study has shown that it is not a substitute for the job task battery, and a rating of "excellent" on the PRT is not a suitable basis for deciding suitability for the job.

It should be noted that the results of this study show that a 3-mile run offers no advantages over the 1.5-mile run as an indicator of readiness to carry out EOD work. Additionally, pull-ups are not as good as push-ups as readiness indicators. Their relationship to job task performance does not provide a suitable basis for continuing to include these measures in EOD PRTs.

The 1,000-yard bay swim is significantly related to performance on the fin swim task. However, in the absence of standards for performance on the fin swim, there is no basis for setting standards on the 1,000-yard bay swim.

Conclusions

From the findings of this study we conclude: (1) PRT items are not good indicators of physical readiness for EOD job tasks; (2) readiness for EOD work can best be assessed by administration of the job tasks developed for this study; (3) maintenance of a score of "excellent" or better on the PRT is a rough indicator of suitability for EOD work; (4) a strength or power test may have utility in predicting readiness for EOD work. This is borne out by the finding that fat-free mass had the greatest correlations among the predictors with job task performance, and because the job tasks are of such short duration, that aerobic processes are not key to performance. Finally, (5) no suitable basis exists for adding extra measures (e.g., pull-ups, 3-mile run) to the PRT for EOD personnel.

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13. ABSTRACT *(Maximum 200 words)*
The purpose of this study was to explore relationships between performance of EOD job tasks and physical fitness measures and to determine minimum physical fitness scores, to serve as standards for EOD personnel. Subjects were 47 active-duty EOD personnel. Mean age was 31.8 ±5.8 years; stature, 177.4 ±5.8 cm; body mass, 81.1 ±10.9 kg; and body fat content, 17.1 ±5.3 %. Physical fitness attributes measured were: Sit-reach distance, push-ups in 2 min, curl-ups in 2 min, pull-ups, long jump, 1.5-mile run, 3.0-mile run, 500-yd pool swim, and 1,000-yd ocean swim. Performance on 4 job task simulations was measured as time for task completion: (1) carrying diving equipment; (2) lifting twin-80 SCUBA tanks; (3) 500-yd bay surface swim; and (4) 100-yd rescue swim. Fat-free mass was a significant predictor ($p < 0.05$) of performance on all of the job task simulations. Body mass was a significant predictor of performance on the SCUBA tank lift, bay swim time, and rescue swim time. Stature was related significantly to equipment carry time and bay swim time. The PRT items were, in general, poor predictors of performance on the job task simulations. The only significant prediction was push-ups for performance on the bay swim and rescue swim.

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